Absolute Spectroradiometric Calibration of Standard Stars

John Woodward, Steven Brown, Allan Smith,
Claire Cramer, and Keith Lykke
National Institute of Standards and Technology

John McGraw and Peter Zimmer
University of New Mexico

Emilio Falco, Christopher Stubbs
Harvard-Smithsonian Center for Astrophysics

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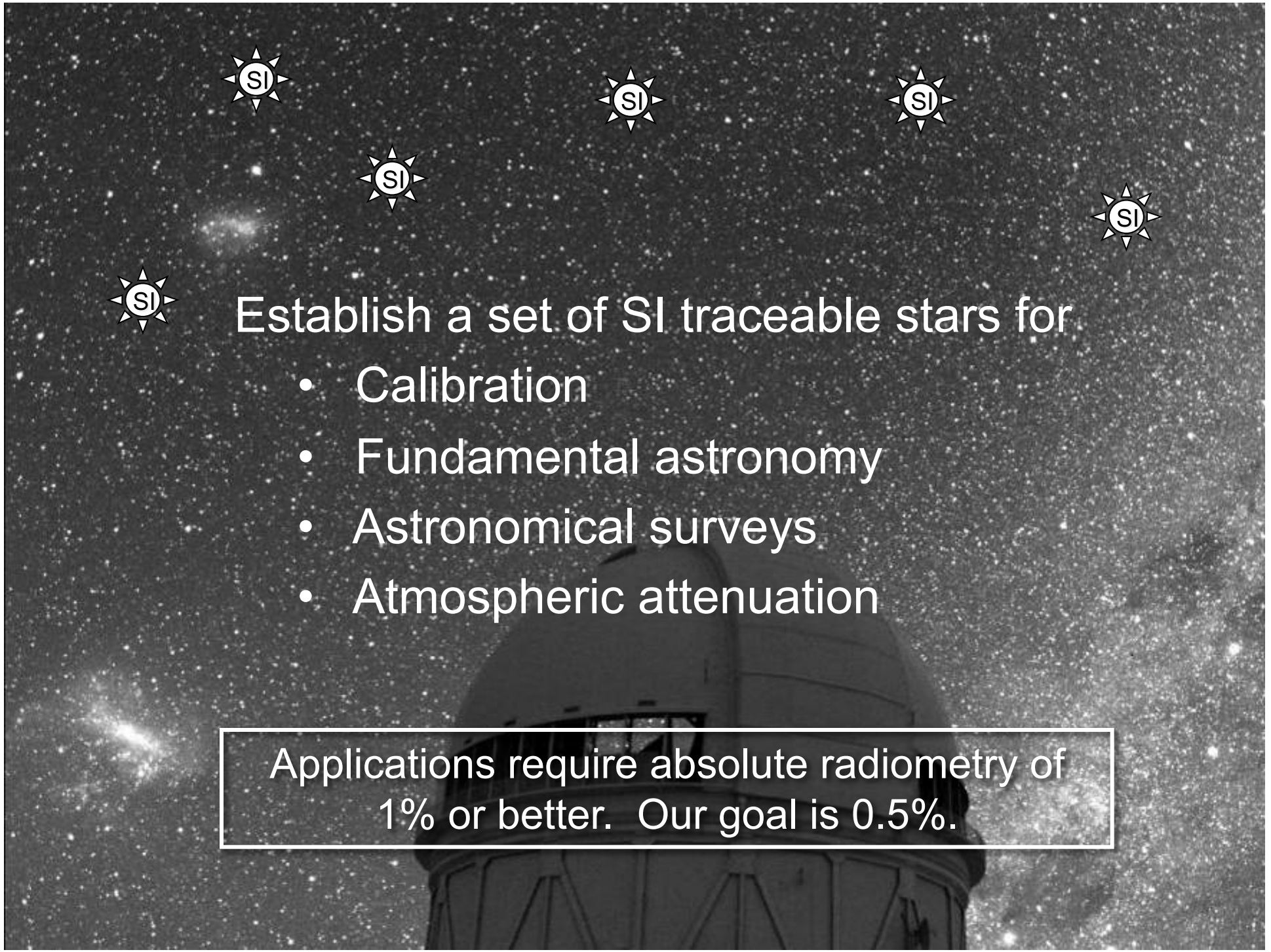


Establish a set of SI traceable stars for

- Calibration
- Fundamental astronomy
- Astronomical surveys
- Atmospheric attenuation

Applications require absolute radiometry of 1% or better. Our goal is 0.5%.

Why Now?

- SI traceable calibration of Vega performed by Hayes and Latham (1975).
- Calibrations based on stellar modeling (e.g. white dwarfs Koester (1995)) lack SI traceability.
- Improvements in radiometry and in atmospheric modeling and measurement.

Program Overview

- Refine the Hayes & Latham technique by redesigning the terrestrial light source
- Make a direct measurement of the horizontal transmission along the path from source to telescope during source observation.
- Monitor atmospheric transmission during observations of stars (previous talk).

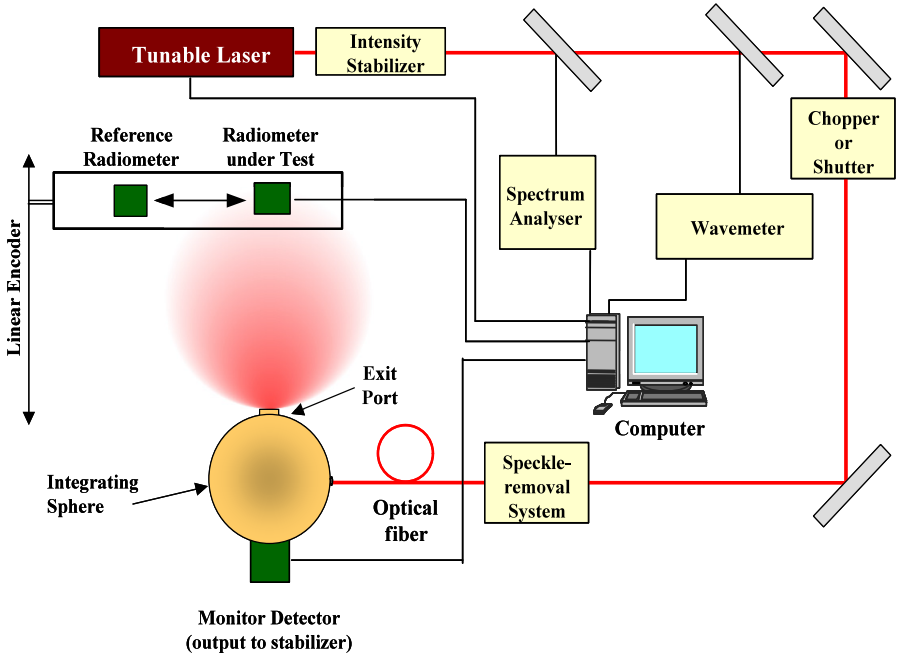
Pieces of the Puzzle

- Source design and calibration.
- Telescope/spectrograph/camera calibration.
- Horizontal atmospheric transmission.
- Vertical atmospheric transmission.

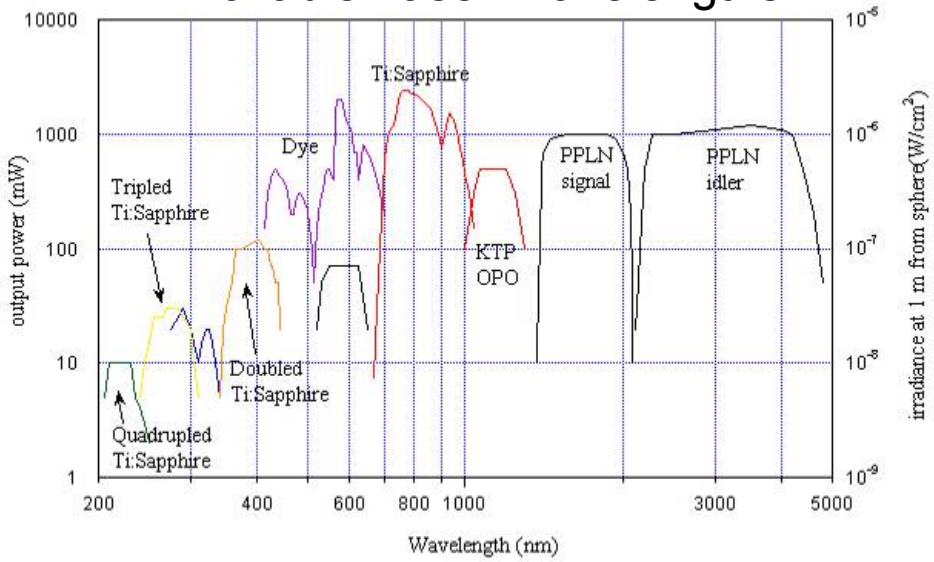
Optical Radiation Standards: SIRCUS

SIRCUS is a laser-based calibration facility with the lowest uncertainties in the world for calibrating the radiance or irradiance responsivity of optical sensors.

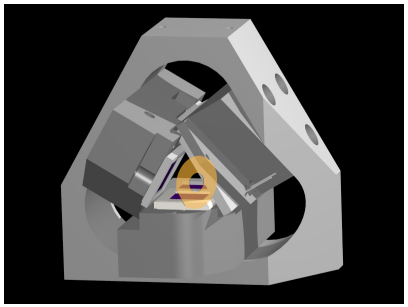
SIRCUS Schematic

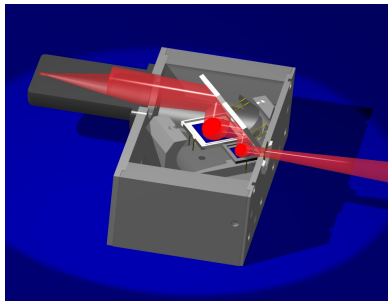


Available Laser Wavelengths



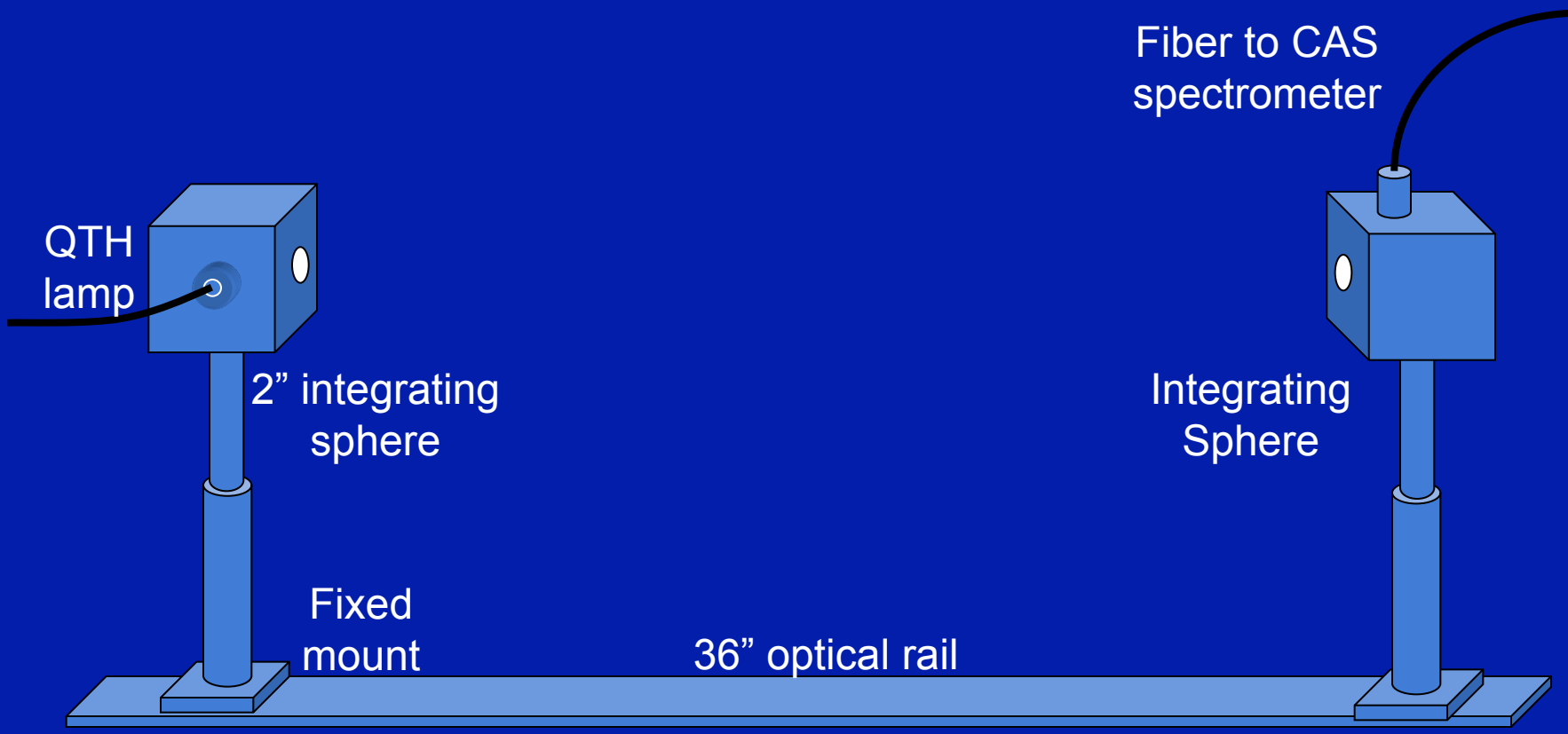
Si tunnel-trap transfer standard detector





http://physics.nist.gov/Divisions/Div844/facilities/sircus/sircus.html

Integrating Sphere Source



Pieces of the Puzzle

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- Telescope/spectrograph/camera calibration.
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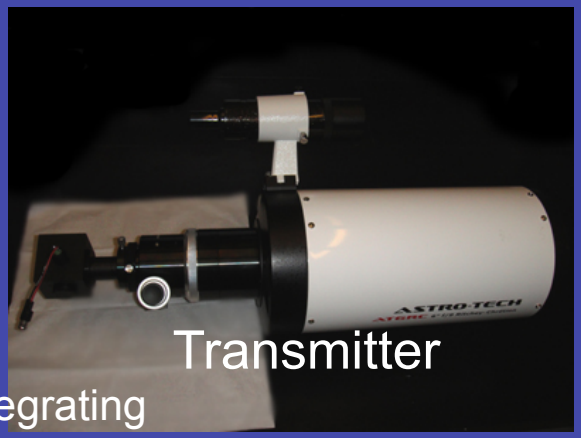
Horizontal Atmospheric Transmittance

- Original Plan – Use 10” telescope to observe summit source and focus onto optical fiber feeding a spectrometer.

  Did not meet reproducibility requirement.

- New Plan – Use paired telescopes to create a collimated source and receiver.

Horizontal Transmittance Setup



Integrating sphere with lamp

6” RC telescope

6” RC telescope

½” integrating sphere

Monitor spectrometer

CAS spectrometer

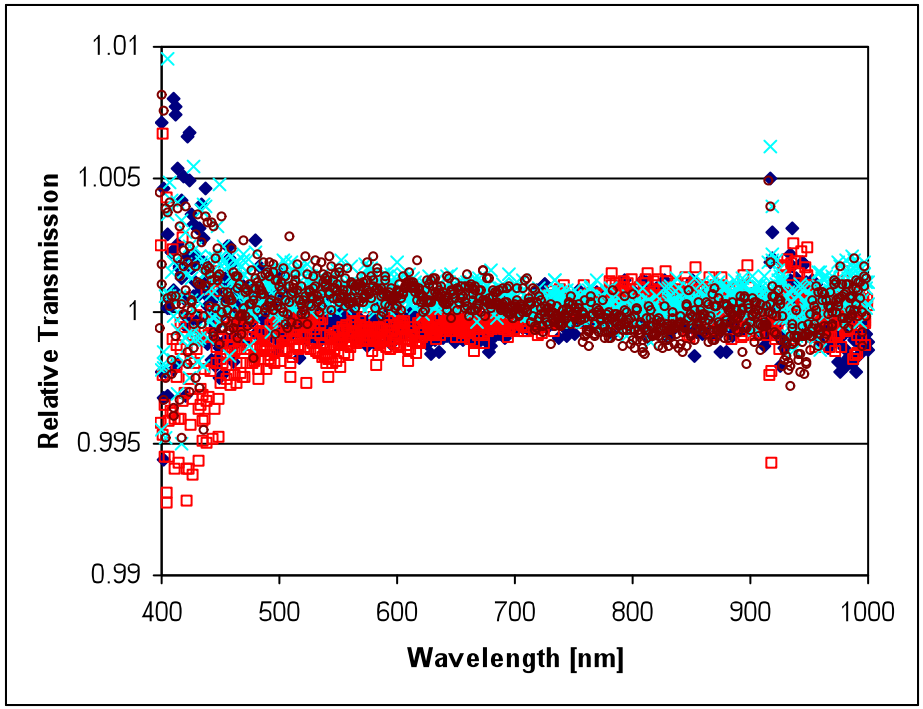
Ratio of spectra collected with telescopes near and far yields the transmittance

Reproducibility

Telescopes set up inside at 158 m separation and 1 m separation.

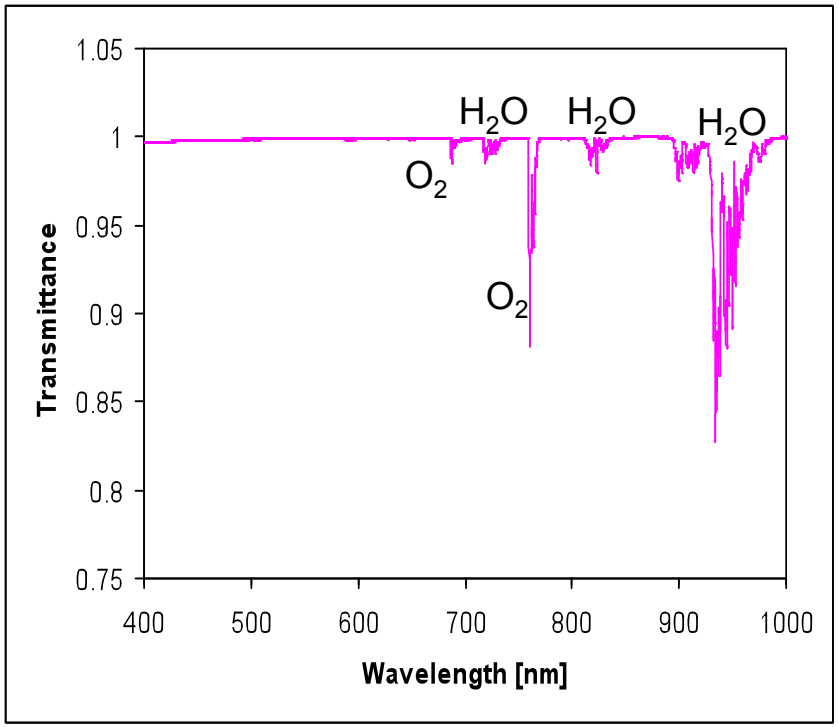
Telescopes aligned using “noise maker” on receiver and walkie-talkie.

Relative spectral reproducibility is better than 0.5%.

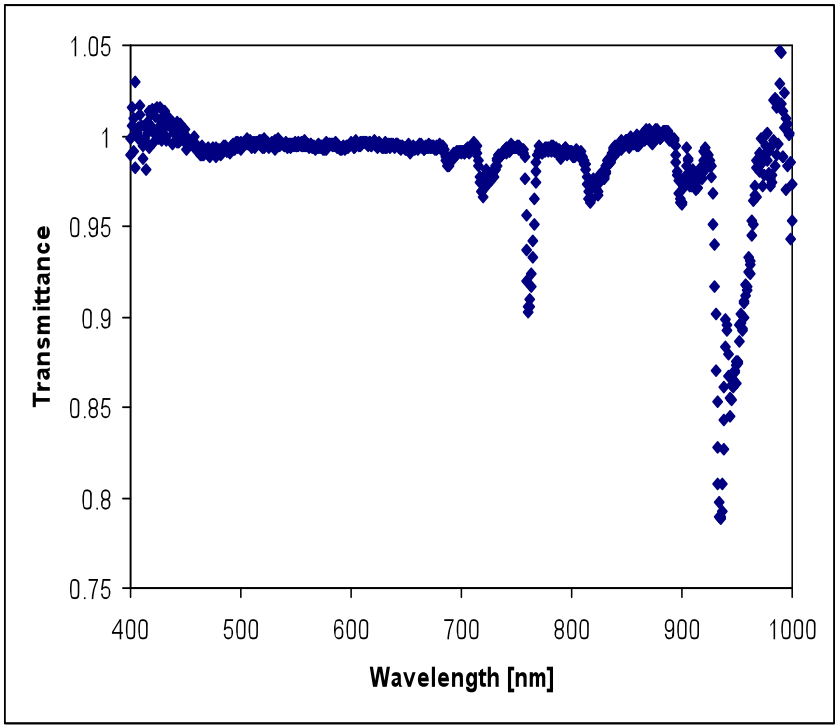


Atmospheric Transmission

Modtran model



Measured



Pieces of the Puzzle

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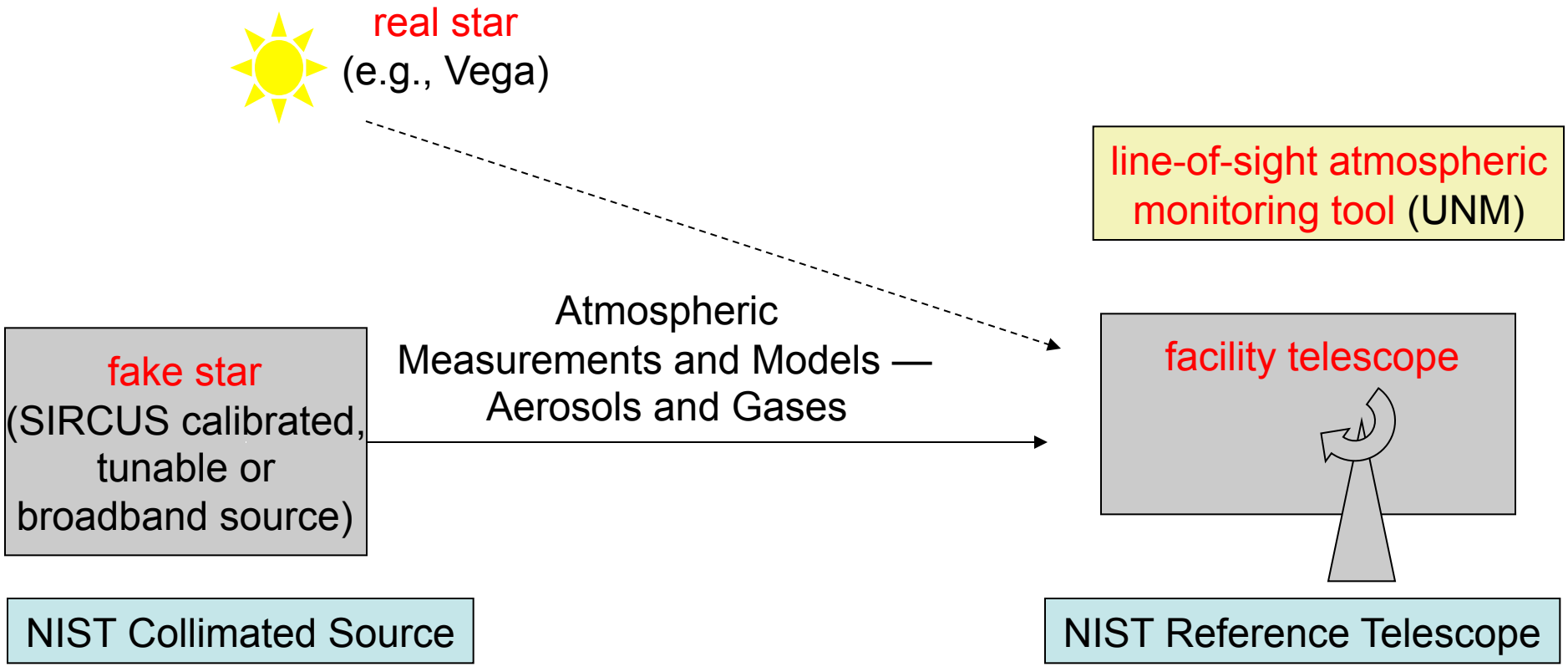
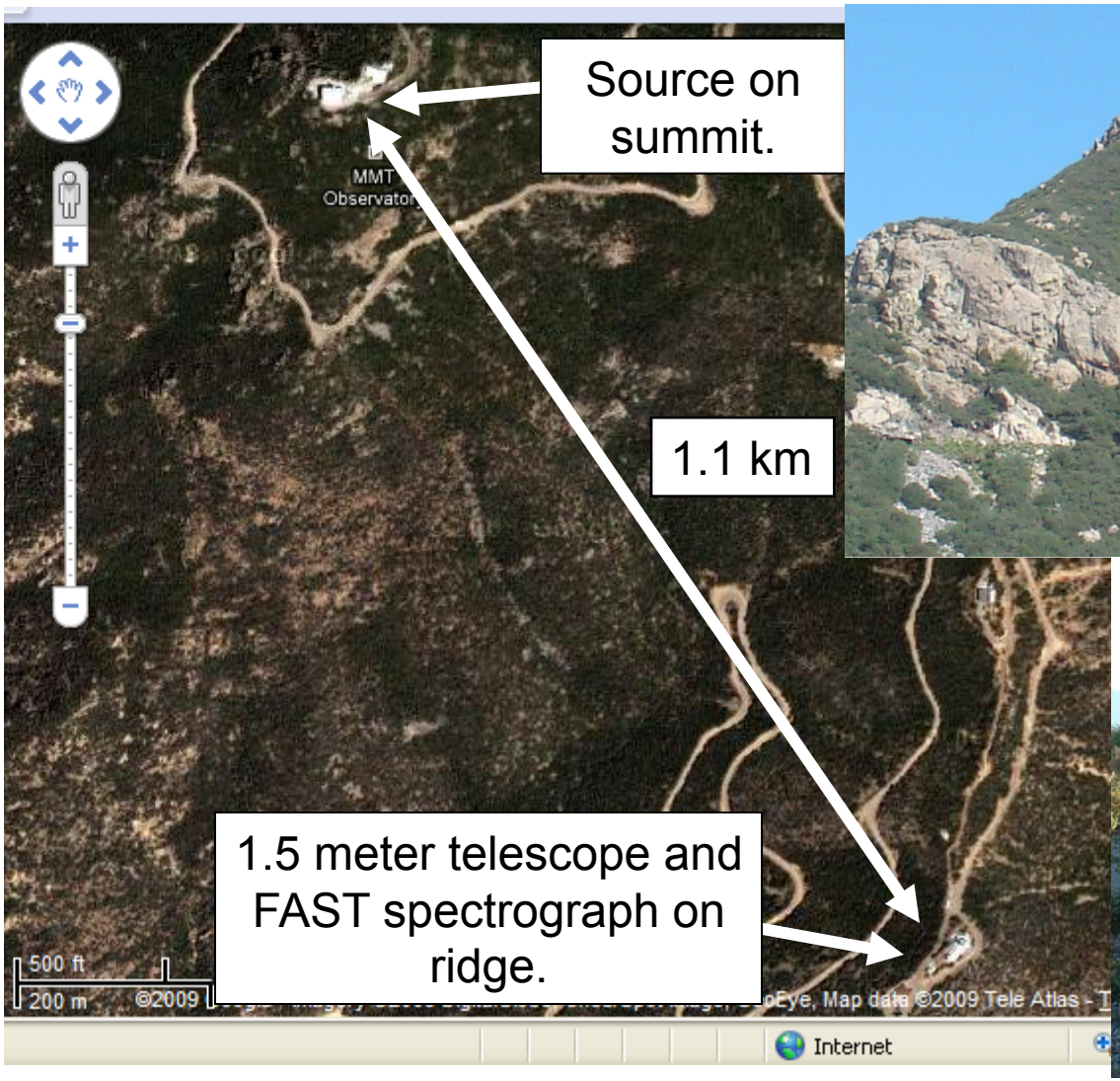
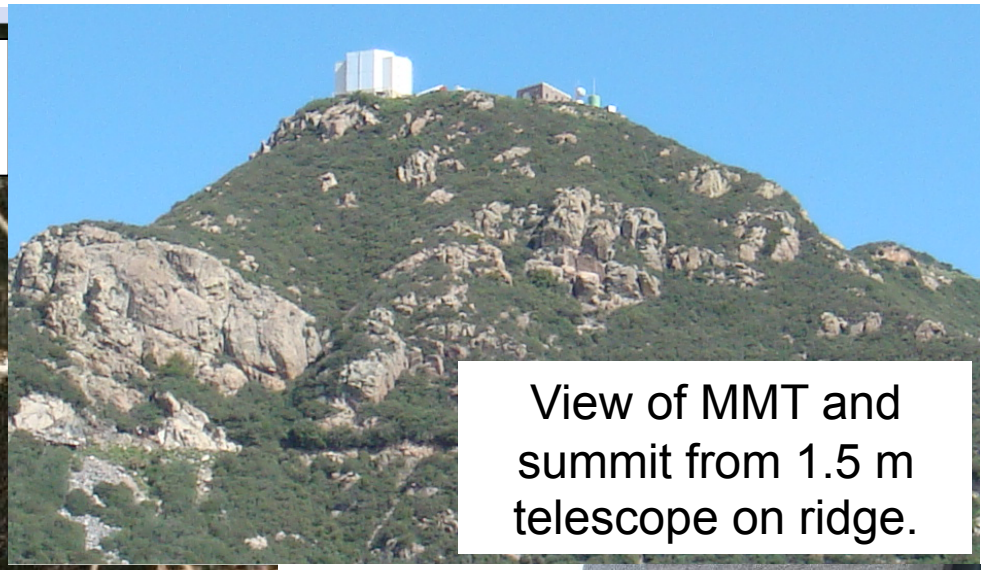
Putting the Pieces Together



1. Observe calibrated source with facility telescope
2. Check that the reference telescope measurement agrees with lidar, model
   → Sanity check on atmospheric monitor, facility telescope calibration
3. Observe real stars with facility telescope while monitoring atmospheric transmission

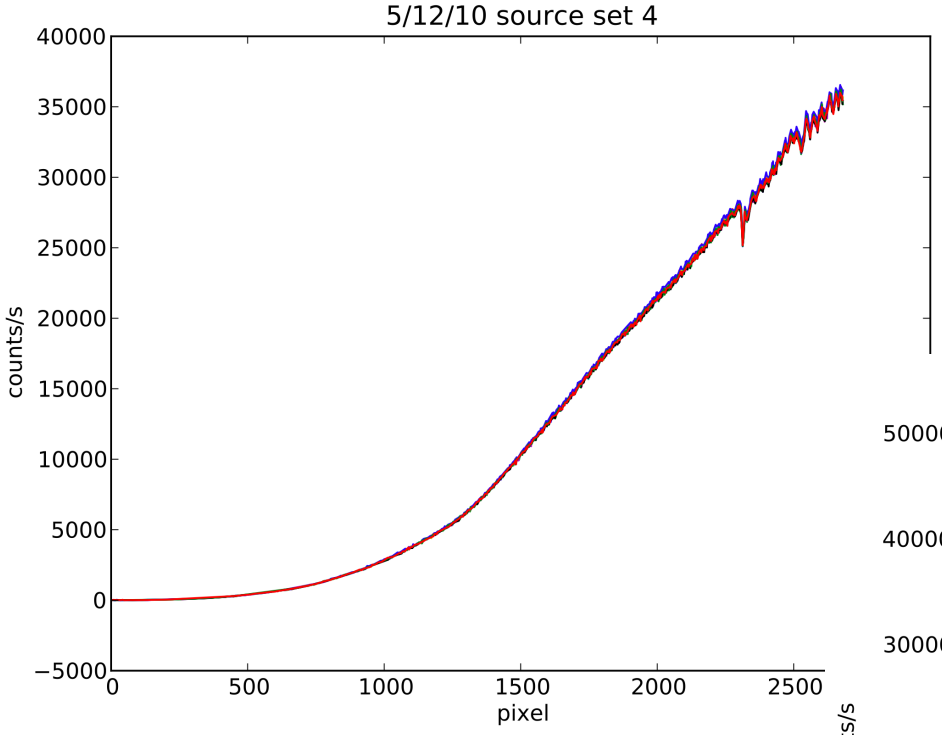
Mount Hopkins

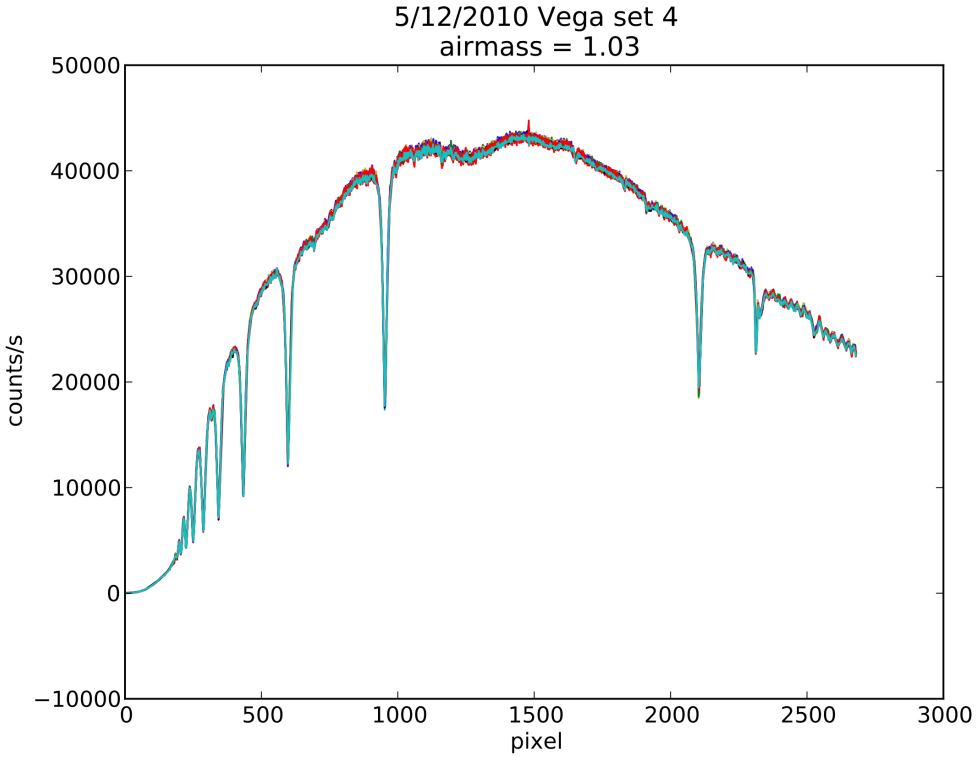




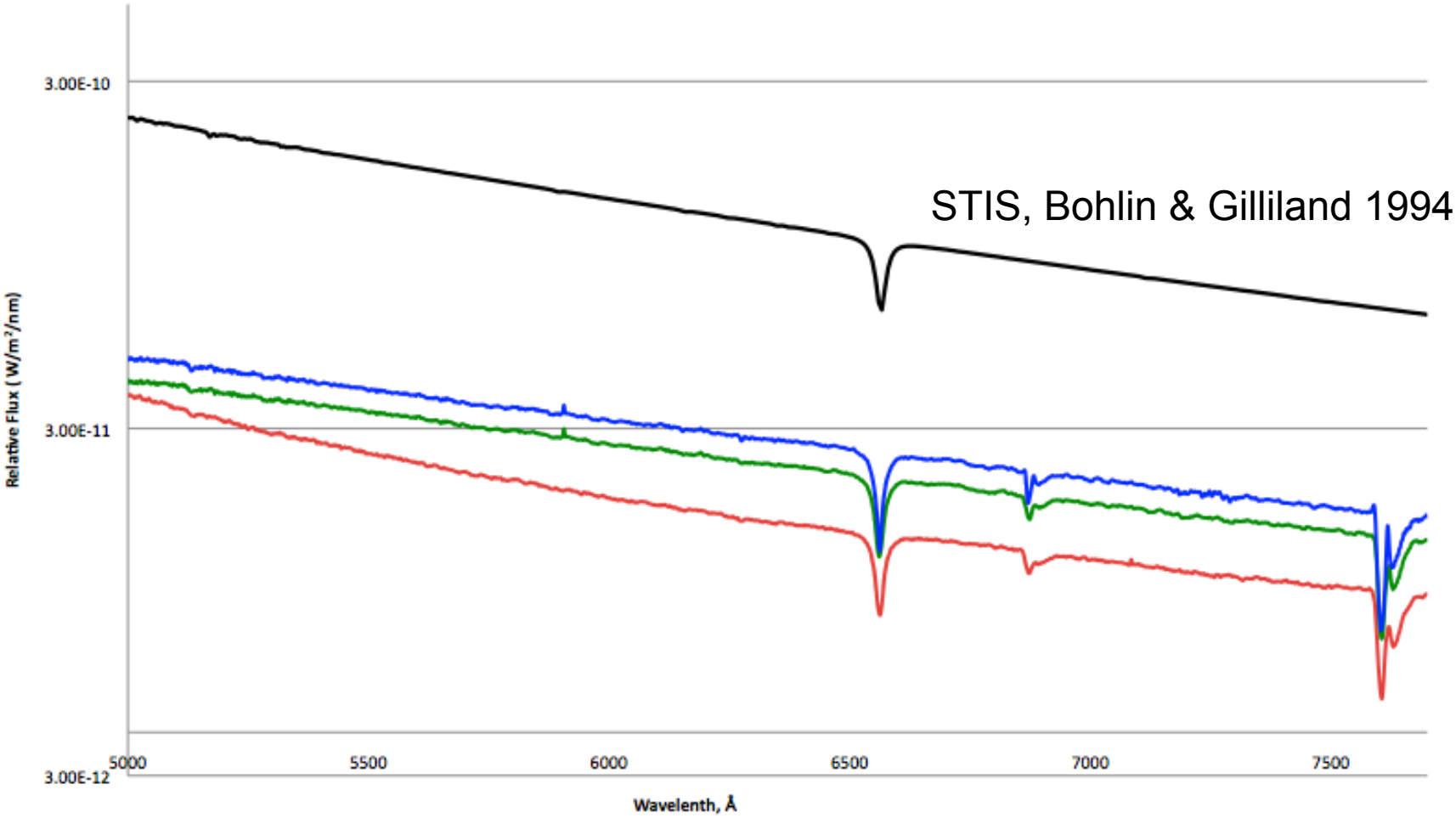
View of MMT and summit from 1.5 m telescope on ridge.

Sample Spectra





Preliminary Calibration of Vega



Next Steps

Integrate the Pieces of the Puzzle:

Make simultaneous line-of-sight atmospheric transmission measurements, match with models

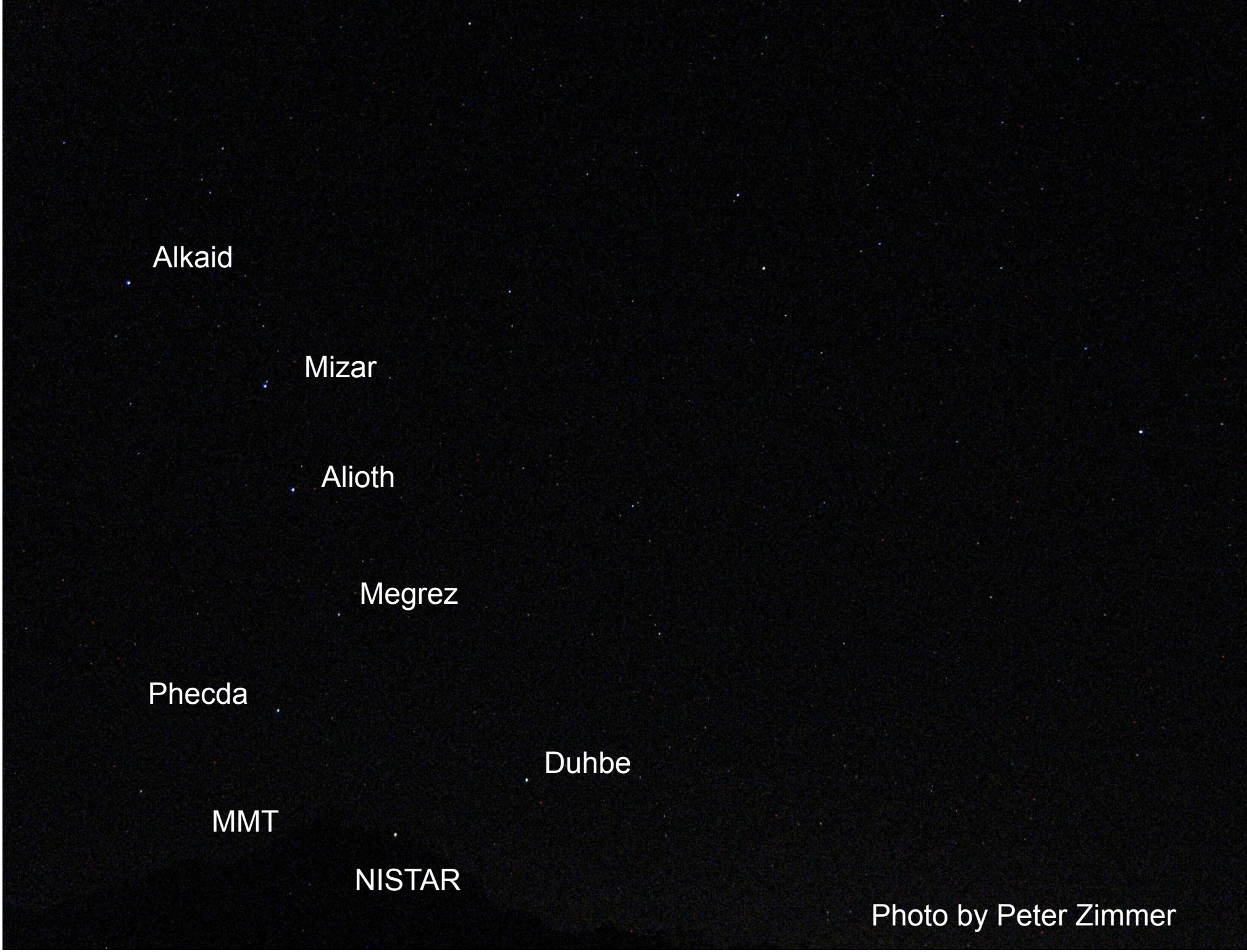
Cross-check with Space-Based Observations

Extend the Technique to Fainter Targets
(e.g., LSST needs m > 18)

Summary

NIST is undertaking a campaign to establish a catalog of stars with precise SI traceable spectrophotometric calibration.

We seek input from the community to ensure that the methodology is sound and accepted and that the catalog is widely used.


Alkaid
Mizar
Alioth
Megrez
Phecda
Duhbe
MMT
NISTAR
Photo by Peter Zimmer